Yale Carbon Containment Lab

TO: Department of Ecology
FROM: Yale Carbon Containment Lab and Cascadia Law Group, PLLC
DATE: May 23, 2022
RE: Justification for Injecting More Than 1000 MT $scCO_2$ under WAC 173-218-115(4)(b)(iii)(E)

In March 2022, the Yale Carbon Containment Lab (YCCL) and the Department of Ecology discussed YCCL's Carbon TrapRock Project, including YCCL's need to inject more than 1,000 metric tonnes (MT) of supercritical carbon dioxide ($scCO_2$) into basalt formations in the Columbia River Basalt Group (CRBG). Ecology may permit a Class V pilot well injecting additional volumes of CO_2 when doing so is necessary for determining the feasibility and risks of the project. *See* WAC 173-218-115(4)(b)(iii)(E). The following analysis further explains YCCL's need to inject 10,000 to 50,000 MT $scCO_2$ per well.

BACKGROUND

In 2013, Pacific Northwest National Laboratory and the Big Sky Carbon Sequestration Partnership tested the viability of long-term CO_2 storage through carbonate mineralization in the formations of the CRBG. Approximately 977 MT of $scCO_2$ were injected at a site in Wallula, WA, into a porous and permeable zone (basalt flow tops/brecciated interflow zones) located at depths of 828 to 887 m (McGrail et al., 2014), under a Class V permit issued by Ecology. Post-injection monitoring and sampling confirmed the occurrence of rapid carbonate mineralization within the injection zone, with approximately 60% of the CO_2 mineralizing within 2 years (White et al., 2020). Subsequent laboratory analysis and modeling indicate this mineralization mechanism could represent a significant CO_2 storage resource in the CRBG (McGrail et al., 2006). While the results of the Wallula pilot test provide positive indications of the efficacy of carbonate mineralization for long-term CO_2 storage, the relatively small volume of $scCO_2$ injected limits the ability to assess the CBRG's viability to store larger volumes at commercial-scale injection rates capable of helping to address the climate crisis.

Washington's Underground Injection Control (UIC) regulations limit CO_2 injection in Class V pilot wells to total volumes of 1,000 MT CO_2, unless Ecology agrees "a larger quantity is necessary to determine the feasibility and risks of a project" (WAC 173-218-115(4)(b)(iii)(E)). Larger-scale test injections are required both for the Carbon TrapRock Project to proceed in a manner protective of human health and the environment and to advance this carbon containment solution.

ANALYSIS

Test injections using larger volumes of $scCO_2$ (e.g., 10,000 to 50,000 MT per pilot well) will enable YCCL to follow a cautious approach by better quantifying the storage capacity of the CRBG, understanding mineralization rates, and developing reactive transport models, and, through further study, de-risking carbonate mineralization as a storage mechanism for future commercial carbon capture and sequestration (CCS) projects.

Larger-scale test injections are necessary for several reasons: to (1) ensure the safety and protection of human health and the environment; (2) assess plume imaging and monitoring techniques in basalt reservoirs; (3) test storage of larger volumes in the CRBG; (4) assess higher injection rates; (5) determine mineralization rates and kinetics associated with larger CO_2 volumes; (6) test CO_2 storage characteristics of the CRBG in areas beyond Wallula; and (7) refine estimates of regional (basin-scale) storage resources.

1. Ensuring Safety and Protection of Human Health and Drinking Water: A Class V permit requires extensive pre-injection characterization and analysis to ensure safety and to protect against any interaction of the CO_2 with underground sources of drinking water (USDWs). Increasing the injection volume from 1,000 MT to 50,000 MT or 100,000 MT will not pose additional risk. Instead, YCCL proposes to take a conservative approach and build on the Wallula pilot test with a series of pilot wells, designed to gather more data about caprock static pressure and plume migration rather than advancing directly to commercialization and much larger volumes of CO_2 at this time. This incremental pilot approach thereby ensures that the project is protective of human health and the environment.

2. Assessing Plume Imaging and Monitoring Techniques in Basalt Reservoirs: To date, nearly all CO_2 pilot test injections and commercial CCS projects have focused on storage in sedimentary formations (GCCSI 2022). Accordingly, techniques used to image and monitor plumes of injected CO_2 have been optimized for these types of lithologies. CO_2 storage in the CRBG may require different monitoring techniques or variations of existing methods due to the characteristics of the basalt formations; for example, seismic imaging is unlikely to provide high-quality images of injected CO_2 as in sedimentary aquifer storage projects. Injection of 1,000 MT CO_2 is too small to reliably test monitoring and imaging techniques in basalt formations. Larger pilot test injections, with larger CO_2 footprints, will allow new methods such as distributed acoustic sensing (DAS) to be developed and tested in basalts. YCCL will aim to test the applicability of DAS and other emerging monitoring technologies in partnership with the University of Calgary's Containment and Monitoring Institute (CaMI) and other experts.

3. Testing Storage of Larger Volumes in the CRBG: The Wallula test injection confirmed that the CRBG can store modest volumes of CO_2. However, the 977 MT CO_2 injected during the Wallula pilot test is far less than the volumes necessary for commercial carbon storage projects, which typically aim for storage of 1 million MT CO_2 or more per well (EPA 2022). A first-order requirement for understanding the CRBG's capacity to help with solving the climate crisis is its ability to store larger volumes of CO_2; thus, larger-scale injections are a fundamental research need.

4. Assessing Higher Injection Rates: During the Wallula pilot test, CO_2 was injected at a rate of approximately 40 MT/day, which is significantly lower than would be required for commercial-scale CO_2 injection. The injection rate was constrained by the hydrogeologic characteristics of the site, which included an interpreted flow barrier in the reservoir approximately 50 m from the injection well that limited the allowable increase in reservoir pressure during injection. The two storage projects with active Class VI permits injected at rates of 300,000 to 1 million MT CO_2/year, equivalent to 800 to 3,000 MT CO_2/day (EPA 2022). Testing the suitability of the CRBG formations to accept higher injection rates is crucial to determining the overall viability of storage in the region.

5. Determining Mineralization Rates and Kinetics Associated with Larger CO_2 Volumes: The injection at Wallula was shown to have significant mineralization over short time scales (~60% CO_2 mineralization over ~24 months (White et al., 2020)). While these results suggest mineralization is a viable mechanism for permanently storing CO_2, uncertainty remains about the rates and scale of mineralization with larger volumes of CO_2 and injection at higher rates. Uncertainties also remain about factors like the reaction kinetics, effects of variations in basalt mineralogy, scale of porosity reduction and associated decrease in permeability/injectivity during mineralization, and variations in the mineralization rates over time during and after the injection period. A pilot injecting larger CO_2 volumes would help to answer these fundamental questions and reduce the uncertainties associated with CO_2 sequestration in basalt.

6. Testing CO_2 Storage Characteristics of the CRBG in Other Areas of the Basin: The Wallula pilot test provided valuable information about the injection and storage characteristics in one small part of the CRBG province. However, the site did not have ideal geologic characteristics and, therefore, may not be representative of the Basin's potential. Test injections in one or more other locations, selected primarily for their geologic characteristics and targeting different structures and subregions, will provide insight into the viability of storage throughout the region and potentially will allow ranking of high-potential storage areas within the larger CRBG. Selection criteria for potential well locations were inherently protective, including optimizing for locations away from deep groundwater wells, target injection depths far below USDWs, distances away from faults, distances from population centers, and locations that would be bounded on all sides by both stratigraphic and structural closures to prevent CO_2 migration beyond that area's extent.

7. Refining Estimates of Regional (Basin-Scale) Storage Resources in the CRBG: Existing estimates of the overall storage capacity of the CRBG are based on averaged large-scale geologic characteristics and thus remain high-level and general. To refine these estimates and provide better projections of actual viable storage volumes across the region, additional characterization and injection tests are required. Injection and storage of 1,000 MT CO_2 is likely possible in many parts of the basin, but these small volumes are unrepresentative of the scale necessary for projects to be commercially viable and to combat climate change. Pilot injections of volumes greater than 1,000 MT are necessary to better understand the potential of the CRBG for the storage of meaningful volumes of CO_2.

References:

US Environmental Protection Agency (EPA). 2022. "Class VI Wells Permitted by EPA." <https://www.epa.gov/uic/class-vi-wells-permitted-epa>.

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